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Vibration Exciter for Soil Compacting Devices

The present invention relates to a vibration exciter for a soil compacting device according to the preamble of patent claim 1.

Vibration exciters of this type are used predominantly in vibration plates, and are known from, for example, EP 0 358 744 B1.

A similar vibration exciter is described in DE 100 38 206 A1. It has two imbalance shafts that are positively coupled and that are capable of rotation in opposite directions, each bearing a stationary imbalance mass as well as an imbalance mass that can be moved rotationally relative to the stationary imbalance mass, and thus with the imbalance shaft. The position of the movable imbalance masses can be actively modified within a large range using adjustment means.

When the imbalance shafts rotate, the cooperation of the different imbalance masses produces a resulting overall force that can be directed in the forward or backward direction of travel as desired by the operator. The change of the direction of travel is effected by adjustment means that control the movable imbalance masses. If the operator wishes to bring the soil compacting device to a standstill, the resulting force of the centrifugal weights is set in the vertical direction. This also means that a well-directed compacting of the soil can be achieved while the machine is standing still.

However, the operator does not always desire a strong compacting of this sort at a locally limited point on the soil. In particular when the vibration plate is moving back and forth, at what is called the reverse point an overly strong and thus disadvantageous compacting of the soil can arise, because the force acting on the soil at this position is at its greatest, whereas during the forward or backward travel of the vibration plate, and the concomitant pivoting of the resultant force vector by, for example, 45° towards the front or towards the back, the force acting on the soil is reduced to 1/%2 of the maximum value.

Although the described arrangements have proven very valuable in compacting soil, sand, or gravel, they can be problematic in the compacting of asphalt or concrete surfaces, because the maximum vertical force prevailing at the reverse point can cause localized indentations that cannot be corrected. Thus, in asphalt rollers the vibration is standardly switched off in reverse operation in order to prevent the roller from sinking too deeply into the asphalt when the direction is changed.

In order to solve this problem, in DE 199 43 391 A1 a vibration exciter is described in which the phase position of the centrifugal weights can be adjusted in such a way that the vertical components of the centrifugal forces produced by the centrifugal weights cancel each other out in each rotational position, while the horizontal components of the centrifugal forces are correspondingly added together in the same direction. This makes it possible for the vibration plate to no longer communicate vertical vibrations to the soil when standing still; rather, via a soil contact plate, shearing stresses are introduced into the soil, with which cracks and pores, for example in an asphalt surface, can advantageously be compacted.

This arrangement has also proved very effective in practice. However, the strong horizontal vibrations that prevail during the standstill operation of the vibration plate are not always pleasant for the operator, and also are not always desired for the compacting of the soil surface.

The present invention is therefore based on the object of developing a vibration exciter of the type named above in such a way that an excessively strong compacting of the soil in standstill operation, due to strong vertical vibrations, can be avoided without exposing the operator or the soil to be compacted to strong countering horizontal vibrations.

According to the present invention, this object is achieved by a vibration exciter having the features of patent claim 1. Advantageous developments are defined in the dependent claims.

A vibration exciter according to the present invention preferably has two imbalance shafts that stand parallel to one another and that can be driven in opposite directions with the same rotational speed, each bearing a stationary imbalance mass and an imbalance mass that can be moved in rotational fashion relative to the stationary imbalance mass and/or to the respective

imbalance shaft. Each of the imbalance shafts has an adjustment means with which the position of each movable imbalance mass can be adjusted in relation to the imbalance shaft that bears it. According to the present invention, the positions of the movable imbalance masses in relation to the imbalance shafts that bear them can be adjusted using the adjustment means in such a way that the centrifugal forces produced by the imbalance masses during the rotation of the imbalance shafts cancel each other out as a whole in each rotational position of the imbalance shafts. This means that while each imbalance mass in itself produces a centrifugal force, the centrifugal forces are however adjusted in terms of direction and magnitude in such a way that they compensate one another in the overall sum. Therefore, in this operating state (standstill position) the vibration exciter produces no vibrations, although the imbalance shafts are rotating.

In this way, it can be achieved in particularly advantageous fashion that the magnitude of the resulting overall centrifugal force, i.e., the vibration strength, can be adjusted dependent on the speed of forward motion of the vibration plate. If the speed is reduced, the effective centrifugal force is also reduced in a corresponding ratio, down to the point at which the machine is standing still, at which point there is no longer any resultant overall centrifugal force, and thus no longer any vibration. In this way, a communication of energy into the soil can be achieved that is very uniform over the surface to be compacted.

In a particular specific embodiment of the present invention, the relative position on each of the imbalance shafts can be adjusted such that the centrifugal forces of the imbalance masses borne by this imbalance shaft cancel each other out in each rotational position of the imbalance shaft. This means that even in operation with only one imbalance shaft a relative position can be achieved in which there is no vibration effect.

In order to achieve a forward motion of the soil compacting device as in known devices, in a preferred specific embodiment of the present invention the relative positions can be modified in such a way that the centrifugal forces of the imbalance masses do not cancel each other out; rather, a resultant overall centrifugal force has a horizontal component. In this way, it is possible to bring about a forward motion of the vibration plate, as is known from the prior art.

When there is a change of direction, for example between a forward and a backward direction of travel, at the transition the already-described standstill position can be taken, in which no vibration is communicated to the soil. In this way, undesirable vertical and/or horizontal vibrations can also be avoided at the reverse point during the change of direction. Because the shifting of the movable imbalance masses is sufficient to produce the resulting centrifugal force with the desired direction and magnitude, in a preferred specific embodiment it is not required that the phase position of the imbalance shafts to one another be modifiable, as is the case for example in the vibration exciter described in DE 100 38 206 A1.

In the context of this description, the term "imbalance mass" is meant abstractly. An imbalance mass can of course also be made up of a plurality of imbalance elements distributed on the respective imbalance shaft.

These and additional advantages and features of the present invention are explained in more detail below with the aid of the accompanying Figures.

Figure 1 shows a section, seen from the top, through a vibration exciter according to the present invention in the standstill position; and

Figure 2 shows schematic sections through two imbalance shafts in different rotational positions, with the respective positions of the imbalance masses.

As was already mentioned, vibration exciters are known in many different embodiments. Also known are what are called phase adjustment devices, as presented for example in DE 199 43 391 A1; these are adjustment devices for setting relative positions between imbalance masses and imbalance shafts. Because the present invention does not relate to the detailed and concrete design of a particular vibration exciter or a particular adjustment device, but rather relates to a relative setting (phase position) that is especially suitable for this purpose but has not been previously known, a detailed description of the vibration exciter is not required.

Nonetheless, on the basis of Figure 1 the design of a vibration exciter according to the present invention will be briefly described.

In a housing 1, two imbalance shafts 2, 3 are mounted so as to be capable of rotation, imbalance shaft 2 being rotationally driven by a drive (not shown).

Imbalance shaft 2 bears imbalance elements 4 and 5, which are connected fixedly with imbalance shaft 2 and form a stationary imbalance mass.

In addition, an imbalance mass 6 that is capable of rotational motion is situated on imbalance shaft 2, and this mass can be rotated relative to imbalance shaft 2 via a hub 7 and bearing 8.

The position relative to one another of movable imbalance mass 6 and imbalance shaft 2 is determined with the aid of an adjustment means 9. The principle of action of such an adjustment means has long been known, and is described for example in DE 100 38 206 A1. Adjustment means 9 essentially comprises a piston 10 that can be displaced axially under hydraulic action, and that can be moved axially back and forth in a hollow area of imbalance shaft 2. Piston 10 bears a cross-bolt 11 that passes through two longitudinal grooves 12 formed in the wall of imbalance shaft 2 and engages in spiral-shaped grooves 13 that are formed on the inner side of hub 7. When piston 10, and therewith cross-bolt 11, are axially displaced, hub 7 thus rotates relative to imbalance shaft 2, as does movable imbalance mass 6 borne by hub 7.

In addition, imbalance shaft 2 bears a toothed wheel 14 that meshes with a toothed wheel 15 that is attached to imbalance shaft 3. Via toothed wheels 14 and 15, the rotational motion of driven imbalance shaft 2 is transmitted in positive fashion to imbalance shaft 3, which thus rotates in the opposite direction but with the same rotational speed.

In the same way as imbalance shaft 2, imbalance shaft 3 bears two imbalance elements 16, 17 that together form a stationary imbalance mass. In addition, an imbalance mass 18 is provided that is capable of rotational motion on imbalance shaft 3, and its position relative to imbalance shaft 3 can be adjusted using an adjustment means 19. Because adjustment means 19 has the same design as adjustment means 9, a detailed description is omitted.

The position of the imbalance mass shown in the sectional view of Figure 1 corresponds to the relative position according to the present invention, in which the individual centrifugal forces produced by the respective imbalance masses and/or imbalance elements cancel each other out as a whole (standstill position). This means that the imbalance effect of imbalance elements 4, 5 and/or 16, 17 on the one hand, and the imbalance effect of movable imbalance masses 6, 18 on the other hand, must be identical in their magnitude but opposed to one another.

The associated mr values (product of mass m x radius r of the center of the imbalance mass) must be correspondingly matched to one another.

As a result, imbalance shafts 2 and 3 can accordingly rotate without resulting in an outwardly effective imbalance, and thus a vibration. However, when movable imbalance masses 6, 18 are displaced by adjustment means 9, 19, this state of equilibrium is canceled, so that the desired vertical and horizontal vibrations for soil compacting can arise.

The various relative positions and the vibration states resulting therefrom are shown in Figure 2. Figure 2 shows highly schematized side view from the right in Figure 1.

The hatched half-circles correspond to movable, i.e. adjustable, imbalance masses 6, 18, while the non-hatched half-circles are intended to correspond to imbalance masses 4, 5 and 16, 17, which are stationary relative to imbalance shafts 2, 3, as can be recognized from field a), "Standstill," in Fig. 2.

The state shown in Figure 1 is contained in line a) of Figure 2 under the caption "Standstill." The direction of rotation of imbalance shafts 2, 3, and thus of the imbalance masses, is represented by curved arrows. Stationary imbalance masses 4, 5 and/or 16, 17 stand respectively opposite movable imbalance masses 6, 18.

In lines a) to d), various rotational states of imbalance shafts 2, 3 are shown, each rotated by 90°. The direction of rotation of imbalance shafts 2, 3 is of course the same each time.

In order to achieve forward motion of the vibration plate (left column of Figure 2), movable imbalance masses 6, 18 are rotated in relation to stationary imbalance masses 4, 5 and/or 16, 17.

In the depicted example, movable imbalance mass 6 has been rotated by 90°relative to stationary imbalance elements 4, 5, as well as to imbalance shaft 2. Moreover, movable imbalance mass 18 has been rotated by 90°relative to stationary imbalance elements 16, 17 on imbalance shaft 3, in the same direction as movable imbalance mass 6. The corresponding state is shown in Figure 2a), in the column "Forward." Here as well, various rotational states of imbalance shafts 2, 3 are shown in the column "Forward," under a) to d).

It can be seen that the centrifugal forces resulting from imbalance masses 4, 5 on the one hand and 6 on the other hand and/or 16, 17 and 18 no longer compensate one another, as was the case for standstill vibration. Rather, the centrifugal forces are superposed in such a way that a resultant force, shown in Figure a), is directed upward and to the left, corresponding to the forward direction.

In Fig. 2c) there arises a corresponding counteraction downward and to the right. In this case, the vibration plate is supported on the soil, and conducts the vibrational energy into the soil.

A backward motion of the vibration plate (to the right in Figure 2) is shown in the right column of Figure 2. For this purpose, movable imbalance masses 6 and 18 have been rotated in relation to imbalance shafts 2, 3 that bear them, in the direction opposite the forward direction and by 90° relative to the standstill position, as can be seen in Figure 2a) in the column "Backward."

In this way, a back-and-forth vibration of the vibration plate upward and to the right or downward and to the left is achieved, resulting in backward travel, as is shown by straight arrows in Figures a) and c) "Backward."

The positions of the imbalance masses shown in Figure 2 are extreme positions. Depending on the construction of adjustment means 9, 19, arbitrary intermediate positions, i.e., displacement angles other than 90°, can be achieved, so that a continuous change between forward travel, standstill operation, and backward travel can be achieved.

For adjustment means 9, 19, it is possible on the one hand to use known means such as hydraulic controlling, electric motors, electromechanical control actuators, etc. Alternatively, in a

simplified specific embodiment a controlling of the movable imbalance masses can take place with the aid of simple tension-compression cables that can be controlled by the operator via a common control unit. This can result in considerable savings of cost even in simpler vibration plates.

In order to achieve a precise change between the individual operating states, the changing of the relative positions using adjustment means 9, 19 should be capable of being carried out in synchronous fashion. If necessary, it can however also additionally be useful to enable individual adjustability of the movable imbalance masses without the requirement of synchronization.

The continuous change between forward and backward travel, in which standstill operation can take place without producing vibration, makes it possible to adapt the magnitude of the resulting centrifugal force, and thus the effective vibration, in a manner proportional to the speed of forward motion of the vibration plate. The slower the vibration plate travels, the smaller is the resulting centrifugal force, until, at a standstill point of the vibration plate, e.g. at the reverse point, no vibrations are introduced into the soil. This proportional dependency results from the design of the vibration exciter according to the present invention, without having to make use of expensive control measures.

Of course, with the vibration exciter according to the present invention it is also possible to assume relative positions other than those shown in Figure 2. Given a corresponding design of adjustment means 9, 19, for example, relative positions can be achieved in which in the standstill position of the vibration plate no vertical vibrations are produced, but strong horizontal vibrations are produced, as is known from DE 199 43 391 A1.

The present invention has been explained in relation to an example of a vibration exciter according to Figure 1. Of course, the underlying principle of the present invention can also be applied to other vibration exciters, for example comprising a plurality of movable imbalance masses or a different number of imbalance shafts.